

## Lab 11.6.1: Basic OSPF Configuration Lab (Cabrillo Version)

### Learning Objectives

Upon completion of this lab, you will be able to:

- Cable a network according to the Topology Diagram
- Erase the startup configuration and reload a router to the default state
- Perform basic configuration tasks on a router
- Configure and activate interfaces
- Configure OSPF routing on all routers
- Configure OSPF router IDs
- Verify OSPF routing using show commands
- Configure a static default route
- Propagate default route to OSPF neighbors
- Configure OSPF Hello and Dead Timers
- Configure OSPF on a Multi-access network
- Configure OSPF priority
- Understand the OSPF election process
- Document the OSPF configuration

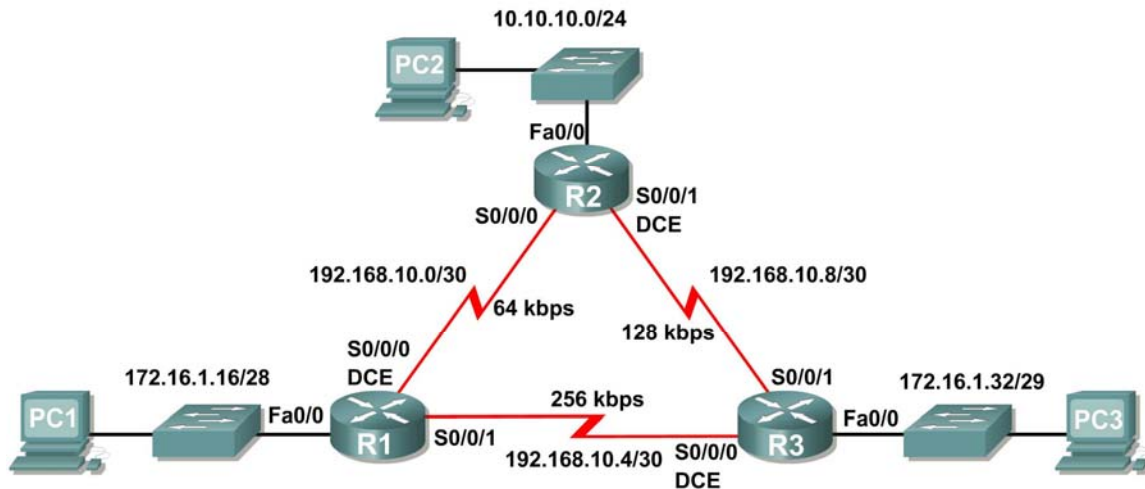
### Scenarios

In this lab activity, there are two separate scenarios. In the first scenario, you will learn how to configure the routing protocol OSPF using the network shown in the Topology Diagram in Scenario A. The segments of the network have been subnetted using VLSM. OSPF is a classless routing protocol that can be used to provide subnet mask information in the routing updates. This will allow VLSM subnet information to be propagated throughout the network.

In the second scenario, you will learn to configure OSPF on a multi-access network. You will also learn to use the OSPF election process to determine the designated router (DR), backup designated router (BDR), and DROther states.

## Scenario A: Basic OSPF Configuration

### Topology Diagram



### Addressing Table

Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	Fa0/0	172.16.1.17	255.255.255.240	N/A
	S0/0/0	192.168.10.1	255.255.255.252	N/A
	S0/0/1	192.168.10.5	255.255.255.252	N/A
R2	Fa0/0	10.10.10.1	255.255.255.0	N/A
	S0/0/0	192.168.10.2	255.255.255.252	N/A
	S0/0/1	192.168.10.9	255.255.255.252	N/A
R3	Fa0/0	172.16.1.33	255.255.255.248	N/A
	S0/0/0	192.168.10.6	255.255.255.252	N/A
	S0/0/1	192.168.10.10	255.255.255.252	N/A
PC1	NIC	172.16.1.20	255.255.255.240	172.16.1.17
PC2	NIC	10.10.10.10	255.255.255.0	10.10.10.1
PC3	NIC	172.16.1.35	255.255.255.248	172.16.1.33

### Task 1: Prepare the Network.

#### Step 1: Cable a network that is similar to the one in the Topology Diagram.

You can use any current router in your lab as long as it has the required interfaces shown in the topology.

**Note:** If you use 1700, 2500, or 2600 routers, the router outputs and interface descriptions will appear different.

**Step 2: Clear any existing configurations on the routers.**

### Task 2: Perform Basic Router Configurations.

Perform basic configuration of the R1, R2, and R3 routers according to the following guidelines:

1. Configure the router hostname.
2. Disable DNS lookup.
3. Configure a privileged EXEC mode password.
4. Configure a message-of-the-day banner.
5. Configure a password for console connections.
6. Configure a password for VTY connections.

### Task 3: Configure and Activate Serial and Ethernet Addresses.

#### Step 1: Configure interfaces on R1, R2, and R3.

Configure the interfaces on the R1, R2, and R3 routers with the IP addresses from the table under the Topology Diagram.

#### Step 2: Verify IP addressing and interfaces.

Use the `show ip interface brief` command to verify that the IP addressing is correct and that the interfaces are active.

When you have finished, be sure to save the running configuration to the NVRAM of the router.

#### Step 3: Configure Ethernet interfaces of PC1, PC2, and PC3.

Configure the Ethernet interfaces of PC1, PC2, and PC3 with the IP addresses and default gateways from the table under the Topology Diagram.

#### Step 4: Test the PC configuration by pinging the default gateway from the PC.

### Note from Rick: Default Bandwidth

On most Cisco routers the default bandwidth for a serial interface default to 1.5 Mbps or 1544 Kbps. The bandwidth value is only used for routing metrics and does not affect the actual speed of the link.

On some of our NetLab routers, we have serial interfaces where the default bandwidth defaults to 128 Kbps. We will set the bandwidth to be the typical default 1544 Kbps value on all serial interfaces so the output you get matches the output in this lab. Later, you will change the bandwidth of each interface to match the actual bandwidth of the link.

Configure the typical default bandwidth of 1544 on all three routers.

```
R1 router:  
R1(config)#interface serial0/0/0
```

```
R1(config-if)#bandwidth 64
R1(config)#interface serial0/0/1
R1(config-if)#bandwidth 256
```

R2 router:

```
R2(config)#interface serial0/0/0
R2(config-if)#bandwidth 64
R2(config)#interface serial0/0/1
R2(config-if)#bandwidth 128
```

R3 router:

```
R3(config)#interface serial0/0/0
R3(config-if)#bandwidth 256
R3(config)#interface serial0/0/1
R3(config-if)#bandwidth 128
```

#### Task 4: Configure OSPF on the R1 Router

**Step 1: Use the router `ospf` command in global configuration mode to enable OSPF on the R1 router.** Enter a process ID of 1 for the *process-ID* parameter.

```
R1(config)#router ospf 1
R1(config-router)#
```

**Step 2: Configure the `network` statement for the LAN network.**

Once you are in the Router OSPF configuration sub-mode, configure the LAN network 172.16.1.16/28 to be included in the OSPF updates that are sent out of R1.

The OSPF **network** command uses a combination of *network-address* and *wildcard-mask* similar to that which can be used by EIGRP. Unlike EIGRP, the wildcard mask in OSPF is required.

Use an area ID of 0 for the OSPF *area-id* parameter. 0 will be used for the OSPF area ID in all of the **network** statements in this topology.

```
R1(config-router)#network 172.16.1.16 0.0.0.15 area 0
R1(config-router)#
```

**Step 3: Configure the router to advertise the 192.168.10.0/30 network attached to the Serial0/0/0 interface.**

```
R1(config-router)# network 192.168.10.0 0.0.0.3 area 0
R1(config-router)#
```

**Step 4: Configure the router to advertise the 192.168.10.4/30 network attached to the Serial0/0/1 interface.**

```
R1(config-router)# network 192.168.10.4 0.0.0.3 area 0
R1(config-router)#
```

**Step 5: When you are finished with the OSPF configuration for R1, return to privileged EXEC mode.**

```
R1(config-router)#end
%SYS-5-CONFIG_I: Configured from console by console
R1#
```

## Task 5: Configure OSPF on the R2 and R3 Routers

**Step 1: Enable OSPF routing on the R2 router using the router ospf command.**  
Use a process ID of 1.

```
R2(config)#router ospf 1
R2(config-router)#
```

**Step 2: Configure the router to advertise the LAN network 10.10.10.0/24 in the OSPF updates.**

```
R2(config-router)#network 10.10.10.0 0.0.0.255 area 0
R2(config-router)#
```

**Step 3: Configure the router to advertise the 192.168.10.0/30 network attached to the Serial0/0/0 interface.**

```
R2(config-router)#network 192.168.10.0 0.0.0.3 area 0
R2(config-router)#
00:07:27: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.10.5 on Serial0/0/0
from EXCHANGE to FULL, Exchange Done
```

Notice that when the network for the serial link from R1 to R2 is added to the OSPF configuration, the router sends a notification message to the console stating that a neighbor relationship with another OSPF router has been established.

**Step 4: Configure the router to advertise the 192.168.10.8/30 network attached to the Serial0/0/1 interface.**

When you are finished, return to privileged EXEC mode.

```
R2(config-router)#network 192.168.10.8 0.0.0.3 area 0
R2(config-router)#end
%SYS-5-CONFIG_I: Configured from console by console
R2#
```

**Step 5: Configure OSPF on the R3 router using the router ospf and network commands.**

Use a process ID of 1. Configure the router to advertise the three directly connected networks. When you are finished, return to privileged EXEC mode.

```
R3(config)#router ospf 1
R3(config-router)#network 172.16.1.32 0.0.0.7 area 0
R3(config-router)#network 192.168.10.4 0.0.0.3 area 0
R3(config-router)#
```

```
00:17:46: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.10.5 on Serial0/0/0
from LOADING to FULL, Loading Done
R3(config-router)#network 192.168.10.8 0.0.0.3 area 0
R3(config-router)#
00:18:01: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.10.9 on Serial0/0/1
from EXCHANGE to FULL, Exchange Done
R3(config-router)#end
%SYS-5-CONFIG_I: Configured from console by console
R3#
```

Notice that when the networks for the serial links from R3 to R1 and R3 to R2 are added to the OSPF configuration, the router sends a notification message to the console stating that a neighbor relationship with another OSPF router has been established.

## Task 6: Configure OSPF Router IDs

The OSPF router ID is used to uniquely identify the router in the OSPF routing domain. A router ID is an IP address. Cisco routers derive the Router ID in one of three ways and with the following precedence:

1. IP address configured with the OSPF **router-id** command.
2. Highest IP address of any of the router's loopback addresses.
3. Highest active IP address on any of the router's physical interfaces.

### Step 1: Examine the current router IDs in the topology.

Since no router IDs or loopback interfaces have been configured on the three routers, the router ID for each router is determined by the highest IP address of any active interface.

What is the router ID for R1? \_\_\_\_\_ **192.168.10.5** \_\_\_\_\_  
What is the router ID for R2? \_\_\_\_\_ **192.168.10.9** \_\_\_\_\_  
What is the router ID for R3? \_\_\_\_\_ **192.168.10.10** \_\_\_\_\_

The router ID can also be seen in the output of the **show ip protocols**, **show ip ospf**, and **show ip ospf interfaces** commands.

R3#**show ip protocols**

```
Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 192.168.10.10
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
```

<output omitted>

R3#**show ip ospf**

```
Routing Process "ospf 1" with ID 192.168.10.10
  Supports only single TOS(TOS0) routes
  Supports opaque LSA
  SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
```

<output omitted>

R3#**show ip ospf interface**

```
FastEthernet0/0 is up, line protocol is up
  Internet address is 172.16.1.33/29, Area 0
  Process ID 1, Router ID 192.168.10.10, Network Type BROADCAST, Cost:
1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 192.168.10.10, Interface address 172.16.1.33
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:00
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
```

<output omitted>

R3#

## Step 2: Use loopback addresses to change the router IDs of the routers in the topology.

R1(config)#**interface loopback 0**

R1(config-if)#**ip address 10.1.1.1 255.255.255.255**

R2(config)#**interface loopback 0**

R2(config-if)#**ip address 10.2.2.2 255.255.255.255**

R3(config)#**interface loopback 0**

R3(config-if)#**ip address 10.3.3.3 255.255.255.255**

### Step 3: Reload the routers to force the new Router IDs to be used.

When a new Router ID is configured, it will not be used until the OSPF process is restarted. Make sure that the current configuration is saved to NRAM, and then use the **reload** command to restart each of the routers..

When the router is reloaded, what is the router ID for R1? 10.1.1.1  
 When the router is reloaded, what is the router ID for R2? 10.2.2.2  
 When the router is reloaded, what is the router ID for R3? 10.3.3.3

### Step 4: Use the **show ip ospf neighbors** command to verify that the router IDs have changed.

R1#**show ip ospf neighbor**

Neighbor ID Interface	Pri	State	Dead Time	Address
10.3.3.3 Serial0/0/1	0	FULL/ -	00:00:30	192.168.10.6
10.2.2.2 Serial0/0/0	0	FULL/ -	00:00:33	192.168.10.2

R2#**show ip ospf neighbor**

Neighbor ID Interface	Pri	State	Dead Time	Address
10.3.3.3 Serial0/0/1	0	FULL/ -	00:00:36	192.168.10.10
10.1.1.1 Serial0/0/0	0	FULL/ -	00:00:37	192.168.10.1

R3#**show ip ospf neighbor**

Neighbor ID Interface	Pri	State	Dead Time	Address
10.2.2.2 Serial0/0/1	0	FULL/ -	00:00:34	192.168.10.9
10.1.1.1 Serial0/0/0	0	FULL/ -	00:00:38	192.168.10.5

### Step 5: Use the **router-id** command to change the router ID on the R1 router.

**Note:** Some IOS versions do not support the **router-id** command. If this command is not available, continue to Task 7.

```
R1(config)#router ospf 1
R1(config-router)#router-id 10.4.4.4
Reload or use "clear ip ospf process" command, for this to take effect
```

If this command is used on an OSPF router process which is already active (has neighbors), the new router-ID is used at the next reload or at a manual OSPF process restart. To manually restart the OSPF process, use the **clear ip ospf process** command.



```
R1#(config-router)#end
R1# clear ip ospf process
Reset ALL OSPF processes? [no]:yes
R1#
```

**Step 6: Use the show ip ospf neighbor command on router R2 to verify that the router ID of R1 has been changed.**

```
R2#show ip ospf neighbor
```

Neighbor ID Interface	Pri	State	Dead Time	Address
10.3.3.3 Serial0/0/1	0	FULL/ -	00:00:36	192.168.10.10
10.4.4.4 Serial0/0/0	0	FULL/ -	00:00:37	192.168.10.1

**Step 7: Remove the configured router ID with the no form of the router-id command.**

```
R1(config)#router ospf 1
R1(config-router)#router-id 10.4.4.4
Reload or use "clear ip ospf process" command, for this to take effect
```

**Step 8: Restart the OSPF process using the clear ip ospf process command.**

Restarting the OSPF process forces the router to use the IP address configured on the Loopback 0 interface as the Router ID.

```
R1(config-router)#end
R1# clear ip ospf process
Reset ALL OSPF processes? [no]:yes
R1#
```

## Task 7: Verify OSPF Operation

**Step 1: On the R1 router, Use the show ip ospf neighbor command to view the information about the OSPF neighbor routers R2 and R3.** You should be able to see the neighbor ID and IP address of each adjacent router, and the interface that R1 uses to reach that OSPF neighbor.

```
R1#show ip ospf neighbor
```

Neighbor ID Interface	Pri	State	Dead Time	Address
10.2.2.2 Serial0/0/0	0	FULL/-	00:00:32	192.168.10.2
10.3.3.3 Serial0/0/1	0	FULL/-	00:00:32	192.168.10.6

```
R1#
```

**Step 2: On the R1 router, use the `show ip protocols` command to view information about the routing protocol operation.**

Notice that the information that was configured in the previous Tasks, such as protocol, process ID, neighbor ID, and networks, is shown in the output. The IP addresses of the adjacent neighbors are also shown.

R1#**show ip protocols**

```
Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 10.1.1.1
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    172.16.1.16 0.0.0.15 area 0
    192.168.10.0 0.0.0.3 area 0
    192.168.10.4 0.0.0.3 area 0
  Routing Information Sources:
    Gateway         Distance      Last Update
    10.2.2.2         110          00:11:43
    10.3.3.3         110          00:11:43
  Distance: (default is 110)
```

R1#

Notice that the output specifies the process ID used by OSPF. Remember, the process ID must be the same on all routers for OSPF to establish neighbor adjacencies and share routing information.

**Task8: Examine OSPF Routes in the Routing Tables**

View the routing table on the R1 router. OSPF routes are denoted in the routing table with an "O".

R1#**show ip route**

Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP

D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area  
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2  
E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP  
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS  
inter area  
\* - candidate default, U - per-user static route, o - ODR  
P - periodic downloaded static route

Gateway of last resort is not set

```
10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       10.1.1.1/32 is directly connected, Loopback0
O       10.10.10.0/24 [110/65] via 192.168.10.2, 00:01:02, Serial0/0/0
172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C       172.16.1.16/28 is directly connected, FastEthernet0/0
O       172.16.1.32/29 [110/65] via 192.168.10.6, 00:01:12, Serial0/0/1
192.168.10.0/30 is subnetted, 3 subnets
```

```
C      192.168.10.0 is directly connected, Serial0/0/0
C      192.168.10.4 is directly connected, Serial0/0/1
O      192.168.10.8 [110/128] via 192.168.10.6, 00:01:12, Serial0/0/1
      [110/128] via 192.168.10.2, 00:01:02, Serial0/0/0
R1#
```

Notice that unlike RIPv2 and EIGRP, OSPF does not automatically summarize at major network boundaries.

## Task 9: Configure OSPF Cost

**Step 1: Use the `show ip route` command on the R1 router to view the OSPF cost to reach the 10.10.10.0/24 network.**

```
R1#show ip route
```

*<output omitted>*

```
      10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C      10.1.1.1/32 is directly connected, Loopback0
O      10.10.10.0/24 [110/65] via 192.168.10.2, 00:16:56, Serial0/0/0
      172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C      172.16.1.16/28 is directly connected, FastEthernet0/0
O      172.16.1.32/29 [110/65] via 192.168.10.6, 00:17:06, Serial0/0/1
      192.168.10.0/30 is subnetted, 3 subnets
C      192.168.10.0 is directly connected, Serial0/0/0
C      192.168.10.4 is directly connected, Serial0/0/1
O      192.168.10.8 [110/128] via 192.168.10.6, 00:17:06, Serial0/0/1
      [110/128] via 192.168.10.2, 00:16:56, Serial0/0/0
R1#
```

**Step 2: Use the `show interfaces serial0/0/0` command on the R1 router to view the bandwidth of the Serial 0/0/0 interface.**

```
R1#show interfaces serial0/0/0
```

```
Serial0/0/0 is up, line protocol is up (connected)
  Hardware is HD64570
  Internet address is 192.168.10.1/30
  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec, rely 255/255, load
  1/255
  Encapsulation HDLC, loopback not set, keepalive set (10 sec)
  Last input never, output never, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0 (size/max/drops); Total output drops: 0
```

*<output omitted>*

On most serial links, the bandwidth metric will default to 1544 Kbits. If this is not the actual bandwidth of the serial link, the bandwidth will need to be changed so that the OSPF cost can be calculated correctly.

**Step 3: Use the `bandwidth` command to change the bandwidth of the serial interfaces of the R1 and R2 routers to the actual bandwidth, 64 kbps.**

R1 router:

```
R1(config)#interface serial0/0/0
R1(config-if)#bandwidth 64
R1(config-if)#interface serial0/0/1
R1(config-if)#bandwidth 64
```

R2 router:

```
R2(config)#interface serial0/0/0
R2(config-if)#bandwidth 64
R2(config)#interface serial0/0/1
R2(config-if)#bandwidth 64
```

**Step 4: Use the `show ip ospf interface` command on the R1 router to verify the cost of the serial links.**

The cost of each of the Serial links is now 1562, the result of the calculation:  $10^8/64,000$  bps.

R1#**show ip ospf interface**

<output omitted>

```
Serial0/0/0 is up, line protocol is up
  Internet address is 192.168.10.1/30, Area 0
  Process ID 1, Router ID 10.1.1.1, Network Type POINT-TO-POINT, Cost:
1562
  Transmit Delay is 1 sec, State POINT-TO-POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:05
  Index 2/2, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1 , Adjacent neighbor count is 1
    Adjacent with neighbor 10.2.2.2
  Suppress hello for 0 neighbor(s)
Serial0/0/1 is up, line protocol is up
  Internet address is 192.168.10.5/30, Area 0
  Process ID 1, Router ID 10.1.1.1, Network Type POINT-TO-POINT, Cost:
1562
  Transmit Delay is 1 sec, State POINT-TO-POINT,
```

<output omitted>

**Step 5: Use the `ip ospf cost` command to configure the OSPF cost on the R3 router.**

An alternative method to using the `bandwidth` command is to use the `ip ospf cost` command, which allows you to directly configure the cost. Use the `ip ospf cost` command to change the bandwidth of the serial interfaces of the R3 router to 1562.

```
R3(config)#interface serial0/0/0
R3(config-if)#ip ospf cost 1562
R3(config-if)#interface serial0/0/1
R3(config-if)#ip ospf cost 1562
```

**Step 6: Use the `show ip ospf interface` command on the R3 router to verify that the cost of the link the cost of each of the Serial links is now 1562.**

R3#**show ip ospf interface**

*<output omitted>*

```
Serial0/0/1 is up, line protocol is up
  Internet address is 192.168.10.10/30, Area 0
  Process ID 1, Router ID 10.3.3.3, Network Type POINT-TO-POINT, Cost:
1562
  Transmit Delay is 1 sec, State POINT-TO-POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:06
  Index 2/2, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1 , Adjacent neighbor count is 1
    Adjacent with neighbor 10.2.2.2
  Suppress hello for 0 neighbor(s)
Serial0/0/0 is up, line protocol is up
  Internet address is 192.168.10.6/30, Area 0
  Process ID 1, Router ID 10.3.3.3, Network Type POINT-TO-POINT, Cost:
1562
  Transmit Delay is 1 sec, State POINT-TO-POINT,
<output omitted>
```

## Task 10: Redistribute an OSPF Default Route

**Step 1: Configure a loopback address on the R1 router to simulate a link to an ISP.**

R1(config)#**interface loopback1**

```
%LINK-5-CHANGED: Interface Loopback1, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback1, changed
state to up
```

R1(config-if)#**ip address 172.30.1.1 255.255.255.252**

**Step 2: Configure a static default route on the R1 router.**

Use the loopback address that has been configured to simulate a link to an ISP as the exit interface.

```
R1(config)#ip route 0.0.0.0 0.0.0.0 loopback1
R1(config)#
```

**Step 3: Use the `default-information originate` command to include the static route in the OSPF updates that are sent from the R1 router.**

```
R1(config)#router ospf 1
R1(config-router)#default-information originate
R1(config-router)#
```

**Step 4: View the routing table on the R2 router to verify that the static default route is being redistributed via OSPF.**

```
R2#show ip route
```

*<output omitted>*

Gateway of last resort is 192.168.10.1 to network 0.0.0.0

```

    10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       10.2.2.2/32 is directly connected, Loopback0
C       10.10.10.0/24 is directly connected, FastEthernet0/0
    172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
O       172.16.1.16/28 [110/1563] via 192.168.10.1, 00:29:28,
Serial0/0/0
O       172.16.1.32/29 [110/1563] via 192.168.10.10, 00:29:28,
Serial0/0/1
    192.168.10.0/30 is subnetted, 3 subnets
C       192.168.10.0 is directly connected, Serial0/0/0
O       192.168.10.4 [110/3124] via 192.168.10.10, 00:25:56,
Serial0/0/1
                                     [110/3124] via 192.168.10.1, 00:25:56, Serial0/0/0
C       192.168.10.8 is directly connected, Serial0/0/1
O*E2 0.0.0.0/0 [110/1] via 192.168.10.1, 00:01:11, Serial0/0/0
R2#
```

## Task 11: Configure Additional OSPF Features

**Step 1: Use the `auto-cost reference-bandwidth` command to adjust the reference bandwidth value.**

Increase the reference bandwidth to 10000 to simulate 10GigE speeds. Configure this command on all routers in the OSPF routing domain.

```
R1(config-router)#auto-cost reference-bandwidth 10000
% OSPF: Reference bandwidth is changed.
Please ensure reference bandwidth is consistent across all
routers.
```

```
R2(config-router)#auto-cost reference-bandwidth 10000
% OSPF: Reference bandwidth is changed.
Please ensure reference bandwidth is consistent across all
routers.
```

```
R3(config-router)#auto-cost reference-bandwidth 10000
% OSPF: Reference bandwidth is changed.
Please ensure reference bandwidth is consistent across all
routers.
```

**Step 2: Examine the routing table on the R1 router to verify the change in the OSPF cost metric.**

Notice that the values are much larger cost values for OSPF routes.

```
R1#show ip route
```

<output omitted>

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

```
    10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       10.1.1.1/32 is directly connected, Loopback0
O       10.10.10.0/24 [110/65635] via 192.168.10.2, 00:01:01,
Serial0/0/0
    172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
C       172.16.1.16/28 is directly connected, FastEthernet0/0
O       172.16.1.32/29 [110/65635] via 192.168.10.6, 00:00:51,
Serial0/0/1
    172.30.0.0/30 is subnetted, 1 subnets
C       172.30.1.0 is directly connected, Loopback1
    192.168.10.0/30 is subnetted, 3 subnets
C       192.168.10.0 is directly connected, Serial0/0/0
C       192.168.10.4 is directly connected, Serial0/0/1
O       192.168.10.8 [110/67097] via 192.168.10.2, 00:01:01,
Serial0/0/0
S*    0.0.0.0/0 is directly connected, Loopback1
R1#
```

**Step 3: Use the show ip ospf neighbor command on R1 to view the Dead Time counter.**

The Dead Time counter is counting down from the default interval of 40 seconds.

```
R1#show ip ospf neighbor
```

Neighbor ID	Pri	State	Dead Time	Address
Interface				
10.2.2.2	0	FULL/-	00:00:34	192.168.10.2
Serial0/0/0				
10.3.3.3	0	FULL/-	00:00:34	192.168.10.6
Serial0/0/1				

**Step 4: Configure the OSPF Hello and Dead intervals.**

The OSPF Hello and Dead intervals can be modified manually using the `ip ospf hello-interval` and `ip ospf dead-interval` interface commands. Use these commands to change the hello interval to 5 seconds and the dead interval to 20 seconds on the Serial 0/0/0 interface of the R1 router.

```
R1(config)#interface serial0/0/0
R1(config-if)#ip ospf hello-interval 5
R1(config-if)#ip ospf dead-interval 20
R1(config-if)#
01:09:04: %OSPF-5-ADJCHG: Process 1, Nbr 10.2.2.2 on Serial0/0/0 from
FULL to DOWN, Neighbor Down: Dead timer expired
01:09:04: %OSPF-5-ADJCHG: Process 1, Nbr 10.2.2.2 on Serial0/0/0 from
FULL to Down: Interface down or detached
```

After 20 seconds the Dead Timer on R1 expires. R1 and R2 lose adjacency because the Dead Timer and Hello Timers must be configured identically on each side of the serial link between R1 and R2.

#### Step 5: Modify the Dead Timer and Hello Timer intervals.

Modify the Dead Timer and Hello Timer intervals on the Serial 0/0/0 interface in the R2 router to match the intervals configured on the Serial 0/0/0 interface of the R1 router.

```
R2(config)#interface serial0/0/0
R2(config-if)#ip ospf hello-interval 5
R2(config-if)#ip ospf dead-interval 20
R2(config-if)#
01:12:10: %OSPF-5-ADJCHG: Process 1, Nbr 10.1.1.1 on Serial0/0/0 from
EXCHANGE to FULL, Exchange Done
```

Notice that the IOS displays a message when adjacency has been established with a state of Full.

#### Step 5: Use the show ip ospf interface serial0/0/0 command to verify that the Hello Timer and Dead Timer intervals have been modified.

```
R2#show ip ospf interface serial0/0/0
Serial0/0/0 is up, line protocol is up
  Internet address is 192.168.10.2/30, Area 0
  Process ID 1, Router ID 10.2.2.2, Network Type POINT-TO-POINT, Cost:
1562
  Transmit Delay is 1 sec, State POINT-TO-POINT,
  Timer intervals configured, Hello 5, Dead 20, Wait 20, Retransmit 5
    Hello due in 00:00:00
  Index 3/3, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 1 , Adjacent neighbor count is 1
    Adjacent with neighbor 10.1.1.1
  Suppress hello for 0 neighbor(s)
R2#
```

#### Step 6: Use the show ip ospf neighbor command on R1 to verify that the neighbor adjacency with R2 has been restored.

Notice that the Dead Time for Serial 0/0/0 is now much lower since it is counting down from 20 seconds instead of the default 40 seconds. Serial 0/0/1 is still operating with default timers.

```
R1#show ip ospf neighbor
Neighbor ID      Pri   State           Dead Time   Address
Interface
10.2.2.2         0    FULL/-          00:00:19    192.168.10.2
Serial0/0/0
10.3.3.3         0    FULL/-          00:00:34    192.168.10.6
Serial0/0/1
R1#
```



### **Task 12: Document the Router Configurations.**

On each router, capture the following command output to a text file and save for future reference:

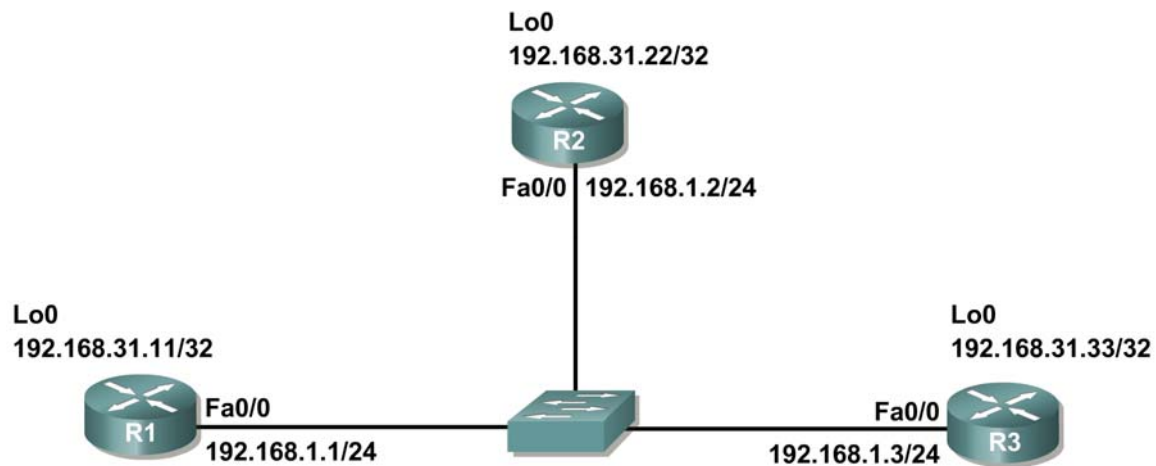
- Running configuration
- Routing table
- Interface summarization
- Output from `show ip protocols`

### **Task 11: Clean Up.**

Erase the configurations and reload the routers. Disconnect and store the cabling. For PC hosts that are normally connected to other networks (such as the school LAN or to the Internet), reconnect the appropriate cabling and restore the TCP/IP settings.

## Scenario B: Configure OSPF on a Multi-access Network

### Topology Diagram



Device	Interface	IP Address	Subnet Mask	Default Gateway
R1	Fa0/0	192.168.1.1	255.255.255.0	N/A
	Loopback1	192.168.31.11	255.255.255.255	N/A
R2	Fa0/0	192.168.1.2	255.255.255.0	N/A
	Loopback1	192.168.31.22	255.255.255.255	N/A
R3	Fa0/0	192.168.1.3	255.255.255.0	N/A
	Loopback1	192.168.31.33	255.255.255.255	N/A

### Task 1: Prepare the Network.

#### Step 1: Cable a network that is similar to the one in the Topology Diagram.

You can use any current router in your lab as long as it has the required interfaces shown in the topology.

**Note:** If you use 1700, 2500, or 2600 routers, the router outputs and interface descriptions will appear different.

In this topology we have three routers sharing a common Ethernet multiaccess network, 192.168.1.0/24. Each router will be configured with an IP address on the Fast Ethernet interface and a loopback address for the router ID.

#### Step 2: Clear any existing configurations on the routers.

## Task 2: Perform Basic Router Configurations.

Perform basic configuration of the R1, R2, and R3 routers according to the following guidelines:

1. Configure the router hostname.
2. Disable DNS lookup.
3. Configure a privileged EXEC mode password.
4. Configure a message-of-the-day banner.
5. Configure a password for console connections.
6. Configure a password for VTY connections

## Task 3: Configure and Activate Ethernet and Loopback Addresses

### Step 1: Configure interfaces on R1, R2, and R3.

Configure the Ethernet and Loopback interfaces on the R1, R2, and R3 routers with the IP addresses from the table under the Topology Diagram. Use the **show ip interface brief** command to verify that the IP addressing is correct. When you have finished, be sure to save the running configuration to the NVRAM of the router.

### Step 2: Verify IP addressing and interfaces.

Use the **show ip interface brief** command to verify that the IP addressing is correct and that the interfaces are active.

When you have finished, be sure to save the running configuration to the NVRAM of the router.

## Task 4: Configure OSPF on the DR Router

The DR and BDR election process takes place as soon as the first router has its interface enabled on the multiaccess network. This can happen as the routers are powered-on or when the OSPF **network** command for that interface is configured. If a new router enters the network after the DR and BDR have already been elected, it will not become the DR or BDR even if it has a higher OSPF interface priority or router ID than the current DR or BDR. Configure the OSPF process on the router with the highest router ID first to ensure that this router becomes the DR.

### Step 1: Use the **router ospf** command in global configuration mode to enable OSPF on the R3 router.

Enter a process ID of 1 for the *process-ID* parameter. Configure the router to advertise the 192.168.1.0/24 network. Use an area ID of 0 for the OSPF *area-id* parameter in the **network** statement.

```
R3(config)#router ospf 1
R3(config-router)#network 192.168.1.0 0.0.0.255 area 0
R3(config-router)#end
R3#
```

### Step 2: Use the **show ip ospf interface** command to verify that the OSPF has been configured correctly and that R3 is the DR.

```
R3#show ip ospf interface
FastEthernet0/0 is up, line protocol is up
Internet address is 192.168.1.3/24, Area 0
```

```

Process ID 1, Router ID 192.168.31.33, Network Type BROADCAST, Cost:
1
Transmit Delay is 1 sec, State DR, Priority 1
Designated Router (ID) 192.168.31.33, Interface address 192.168.1.3
No backup designated router on this network
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
  Hello due in 00:00:07
Index 1/1, flood queue length 0
Next 0x0(0)/0x0(0)
Last flood scan length is 1, maximum is 1
Last flood scan time is 0 msec, maximum is 0 msec
Neighbor Count is 0, Adjacent neighbor count is 0
Suppress hello for 0 neighbor(s)
R3#

```

### Task 5: Configure OSPF on the BDR Router

Configure the OSPF process on the router with the second highest router ID next to ensure that this router becomes the BDR.

**Step 1: Use the `router ospf` command in global configuration mode to enable OSPF on the R2 router.**

Enter a process ID of 1 for the *process-ID* parameter. Configure the router to advertise the 192.168.1.0/24 network. Use an area ID of 0 for the OSPF *area-id* parameter in the **network** statement.

```

R2(config)#router ospf 1
R2(config-router)#network 192.168.1.0 0.0.0.255 area 0
R2(config-router)#end
%SYS-5-CONFIG_I: Configured from console by console
R2#
00:08:51: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.33 on
FastEthernet0/0 from LOADING to FULL, Loading Done

```

Notice that an adjacency is formed with the R3 router. It may take up to 40 seconds for the R3 router to send a hello packet. When this packet is received, the neighbor relationship is formed.

**Step 2: Use the `show ip ospf interface` command to verify that the OSPF has been configured correctly and that R2 is the BDR.**

```

R2#show ip ospf interface
FastEthernet0/0 is up, line protocol is up
  Internet address is 192.168.1.2/24, Area 0
  Process ID 1, Router ID 192.168.31.22, Network Type BROADCAST, Cost:
1
  Transmit Delay is 1 sec, State BDR, Priority 1
  Designated Router (ID) 192.168.31.33, Interface address 192.168.1.3
  Backup Designated Router (ID) 192.168.31.22, Interface address
192.168.1.2
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:03
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1

```

```
Last flood scan time is 0 msec, maximum is 0 msec
Neighbor Count is 1, Adjacent neighbor count is 1
Adjacent with neighbor 192.168.1.3 (Designated Router)
Suppress hello for 0 neighbor(s)
R2#
```

**Step 3: Use the `show ip ospf neighbors` command to view information about the other routers in the OSPF area.**

Notice that R3 is the DR.

```
R2#show ip ospf neighbor
Neighbor ID      Pri   State           Dead Time   Address
Interface
192.168.31.33    1     FULL/DR         00:00:33    192.168.1.3
FastEthernet0/0
```

## Task 6: Configure OSPF on the DRother Router

Configure the OSPF process on the router with the lowest router ID last. This router will be designated as DRother instead of DR or BDR.

**Step 1: Use the `router ospf` command in global configuration mode to enable OSPF on the R1 router.**

Enter a process ID of 1 for the *process-ID* parameter. Configure the router to advertise the 192.168.1.0/24 network. Use an area ID of 0 for the OSPF *area-id* parameter in the **network** statement.

```
R1(config)#router ospf 1
R1(config-router)#network 192.168.1.0 0.0.0.255 area 0
R1(config-router)#end
%SYS-5-CONFIG_I: Configured from console by console
R1#
00:16:08: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.22 on
FastEthernet0/0 from LOADING to FULL, Loading Done
00:16:12: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.33 on
FastEthernet0/0 from EXCHANGE to FULL, Exchange Done
```

Notice that an adjacency is formed with the R2 and R3 routers. It may take up to 40 seconds for both the R2 and R3 routers to each send a hello packet.

**Step 2: Use the `show ip ospf interface` command to verify that the OSPF has been configured correctly and that R1 is a DRother.**

```
R1#show ip ospf interface
FastEthernet0/0 is up, line protocol is up
Internet address is 192.168.1.1/24, Area 0
Process ID 1, Router ID 192.168.31.11, Network Type BROADCAST, Cost:
1
Transmit Delay is 1 sec, State DROTHER, Priority 1
Designated Router (ID) 192.168.31.33, Interface address 192.168.1.3
Backup Designated Router (ID) 192.168.31.22, Interface address
192.168.1.2
Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
```

```

    Hello due in 00:00:00
    Index 1/1, flood queue length 0
    Next 0x0(0)/0x0(0)
    Last flood scan length is 1, maximum is 1
    Last flood scan time is 0 msec, maximum is 0 msec
    Neighbor Count is 2, Adjacent neighbor count is 2
      Adjacent with neighbor 192.168.31.33  (Designated Router)
      Adjacent with neighbor 192.168.31.22  (Backup Designated Router)
    Suppress hello for 0 neighbor(s)
R1#

```

**Step 3: Use the `show ip ospf neighbors` command to view information about the other routers in the OSPF area.**

Notice that R3 is the DR and R2 is the BDR.

```

R1#show ip ospf neighbor
Neighbor ID      Pri   State           Dead Time   Address
Interface
192.168.31.22    1    FULL/BDR        00:00:35    192.168.1.2
FastEthernet0/0
192.168.31.33    1    FULL/DR         00:00:30    192.168.1.3
FastEthernet0/0

```

## Task 7: Use the OSPF Priority to Determine the DR and BDR

**Step 1: Use the `ip ospf priority interface` command to change the OSPF priority of the R1 router to 255.**

This is the highest possible priority.

```

R1(config)#interface fastEthernet0/0
R1(config-if)#ip ospf priority 255
R1(config-if)#end

```

**Step 2: Use the `ip ospf priority interface` command to change the OSPF priority of the R3 router to 100.**

```

R3(config)#interface fastEthernet0/0
R3(config-if)#ip ospf priority 100
R3(config-if)#end

```

**Step 3: Use the `ip ospf priority interface` command to change the OSPF priority of the R2 router to 0.** A priority of 0 causes the router to be ineligible to participate in an OSPF election and become a DR or BDR.

```

R2(config)#interface fastEthernet0/0
R2(config-if)#ip ospf priority 0
R2(config-if)#end

```

**Step 4: Shut down and re-enable the FastEthernet0/0 interfaces to force an OSPF election.** The FastEthernet0/0 interfaces of each of the routers can be shut down and re-enabled to force an OSPF election. Shut down the FastEthernet0/0 interface on each of the three routers. Notice that as the interfaces are shut down the OSPF adjacencies are lost.

**R1:**

```
R1(config)#interface fastethernet0/0
R1(config-if)#shutdown
```

```
%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to
administratively down
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0,
changed state to down
02:17:22: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.22 on
FastEthernet0/0 from FULL to Down: Interface down or detached
02:17:22: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.33 on
FastEthernet0/0 from FULL to Down: Interface down or detached
```

**R2:**

```
R2(config)#interface fastethernet0/0
R2(config-if)#shutdown
```

```
%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to
administratively down
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0,
changed state to down
02:17:06: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.33 on
FastEthernet0/0 from FULL to Down: Interface down or detached
02:17:06: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.11 on
FastEthernet0/0 from FULL to Down: Interface down or detached
```

**R3:**

```
R3(config)#interface fastethernet0/0
R3(config-if)#shutdown
```

```
%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to
administratively down
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0,
changed state to down
02:17:22: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.22 on
FastEthernet0/0 from FULL to Down: Interface down or detached
02:17:22: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.11 on
FastEthernet0/0 from FULL to Down: Interface down or detached
```

**Step 5: Re-enable the FastEthernet0/0 interface on the R2 router.**

```
R2(config-if)#no shut
R2(config-if)#end
%SYS-5-CONFIG_I: Configured from console by console
R2#
```

**Step 6: Re-enable the FastEthernet0/0 interface on the R1 router.**

Notice that an adjacency is formed with the R2 router. It may take up to 40 seconds for the R2 router to send a hello packet.

```
R1(config-if)#no shutdown
```

```
%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0,
changed state to up
```

```
R1(config-if)#end
%SYS-5-CONFIG_I: Configured from console by console
R1#
02:31:43: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.22 on
FastEthernet0/0 from EXCHANGE to FULL, Exchange Done
```

**Step 7: Use the `show ip ospf neighbor` command on the R1 router to view the OSPF neighbor information for that router.**

Notice that even though the R2 router has a higher router ID than R1, the R2 router has been set to a state of DROTHER because the OSPF priority has been set to 0.

```
R1#show ip ospf neighbor
Neighbor ID      Pri   State           Dead Time   Address
Interface
192.168.31.22    0     FULL/DROTHER    00:00:33    192.168.1.2
FastEthernet0/0
R1#
```

**Step 8: Re-enable the FastEthernet0/0 interface on the R3 router.**

Notice that an adjacency is formed with the R1 and R2 routers. It may take up to 40 seconds for both the R1 and R2 routers to each send a hello packet.

```
R3(config-if)#no shutdown

%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0,
changed state to up
R3(config-if)#end
%SYS-5-CONFIG_I: Configured from console by console
02:37:32: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.11 on
FastEthernet0/0 from LOADING to FULL, Loading Done
02:37:36: %OSPF-5-ADJCHG: Process 1, Nbr 192.168.31.22 on
FastEthernet0/0 from EXCHANGE to FULL, Exchange Done
```

**Step 9: Use the `show ip ospf interface` command on the R3 router to verify that R3 has become the BDR.**

```
R3#show ip ospf interface
FastEthernet0/0 is up, line protocol is up
  Internet address is 192.168.1.3/24, Area 0
  Process ID 1, Router ID 192.168.31.33, Network Type BROADCAST, Cost:
  1
  Transmit Delay is 1 sec, State BDR, Priority 100
  Designated Router (ID) 192.168.31.11, Interface address 192.168.1.1
<output omitted>
```



### **Task 8: Document the Router Configurations.**

On each router, capture the following command output to a text file and save for future reference:

- Running configuration
- Routing table
- Interface summarization
- Output from `show ip protocols`

### **Task 9: Clean Up.**

Erase the configurations and reload the routers. Disconnect and store the cabling. For PC hosts that are normally connected to other networks (such as the school LAN or to the Internet), reconnect the appropriate cabling and restore the TCP/IP settings.